UNIVERSITY OF EDUCATION, WINNEBA
DEPARTMENT OF SCIENCE EDUCATION

PHY 361 SOLAR & ATMOSPHERIC PHYSICS
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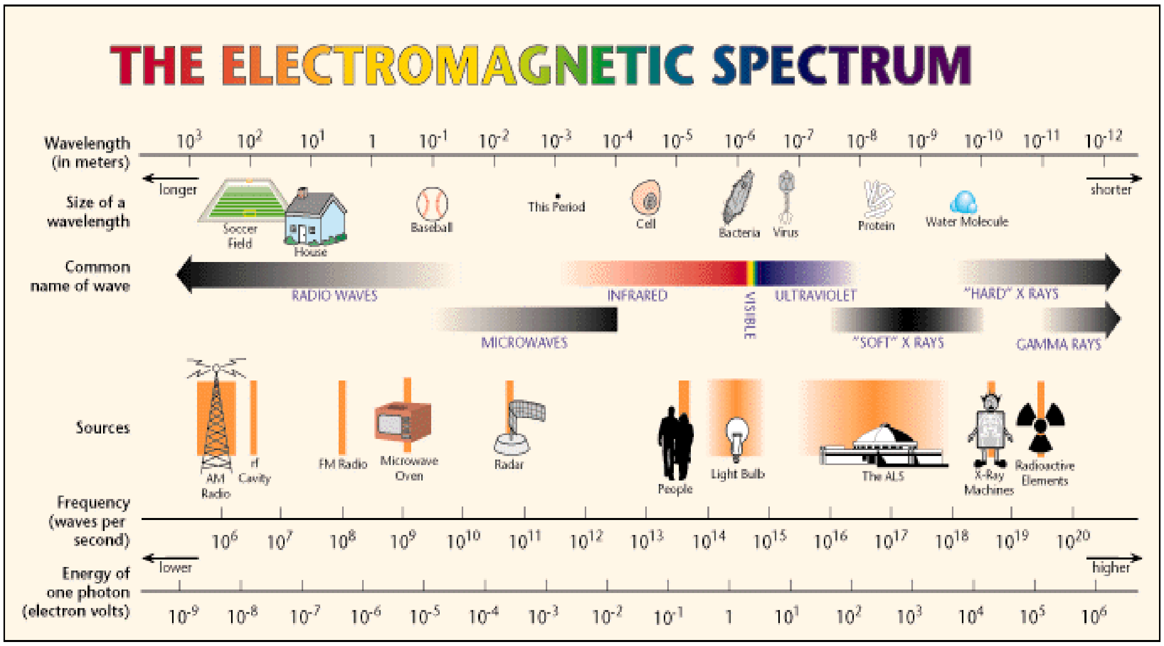
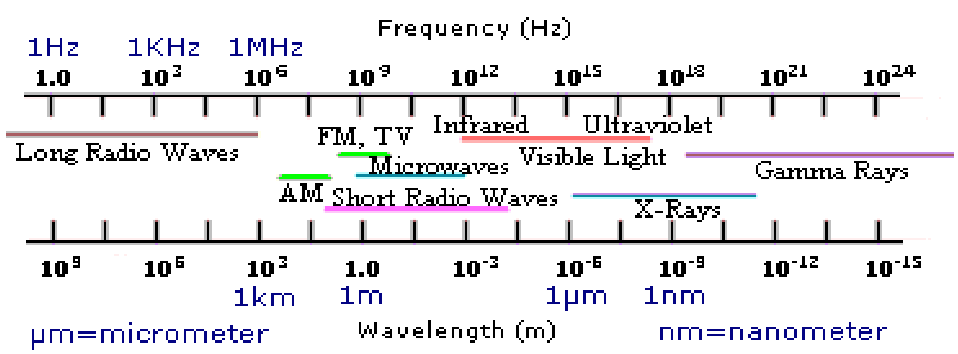
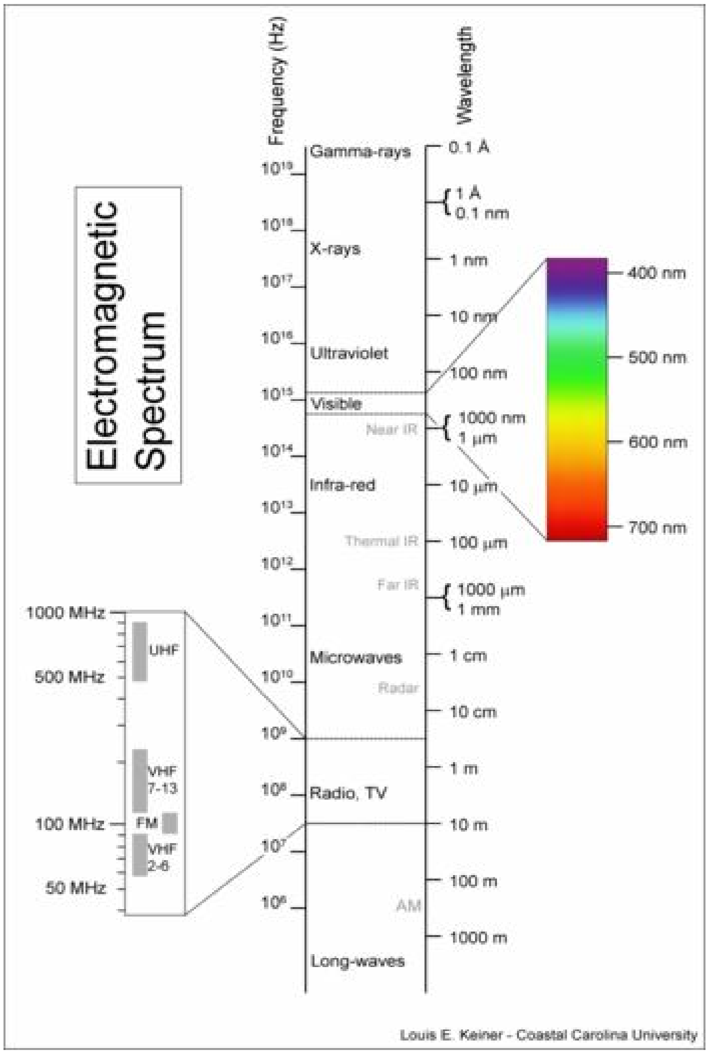
About Solar Energy

Energy from the sun travels to the earth in the form of electromagnetic radiation similar to radio waves, but in a different frequency range.







Available solar energy is often expressed in units of energy per time per unit area, such as watts per square metre (W/m^2). The amount of energy available from the sun outside the Earth's atmosphere is approximately **1367 W/m^2**; that's nearly the same as a high power hair drier for every square meter of sunlight! Some of the solar energy is absorbed as it passes through the Earth's atmosphere. As a result, on a clear day the amount of solar energy available at the Earth's surface in the direction of the sun is typically **1000 W/m^2**. At any particular time, the available solar energy is primarily dependent upon how high the sun is in the sky and current cloud conditions. On a monthly or annual basis, the amount of solar energy available also depends upon the location. Furthermore, useable solar energy is depends upon available solar energy, other weather conditions, the technology used, and the application.

There are many ways that solar energy can be used effectively. Applications of solar energy use can be grouped into there are three primary categories: heating/cooling, electricity production, and chemical processes. The most widely used applications are for water and space heating. **Ventilation solar air heating** is also growing in popularity. Uptake of electricity producing solar technologies is increasing for the applications photovoltaics (primarily) and concentrating solar thermal-electric technologies. Due to recent advances in solar detoxification technologies for cleaning water and air, these applications hold promise to be competitive with conventional technologies.

The advantages of solar energy

Solar energy has the following advantages over conventional energy:

- The energy from the sun is virtually free after the initial cost has been recovered.
- Depending on the utilization of energy, paybacks can be very short when compared to the cost of common energy sources used.
- Solar and other renewable energy systems can be stand-alone; thereby not requiring connection to a power or natural gas grid.
- The sun provides a virtually unlimited supply of solar energy.
- The use of solar energy displaces conventional energy; which usually results in a proportional decrease in green house gas emissions.
- The use of solar energy is an untapped market.

Applications of solar energy

The following table shows some applications of solar energy, who uses it and how the energy is obtained. Not all applications listed exist every country and this is not a complete list of all solar energy applications in use around the world.

What is solar energy used for?	Where is it used?	Which solar technologies are used?	Which secondary technologies are used? (where applicable)
Heating - Water	Homes	Glazed flat plate collectors Batch collectors Vacuum tube collectors	Heat exchanger Hot water tank
	Commercial	Liquid-based collectors	Heat exchanger Medium-large water tank

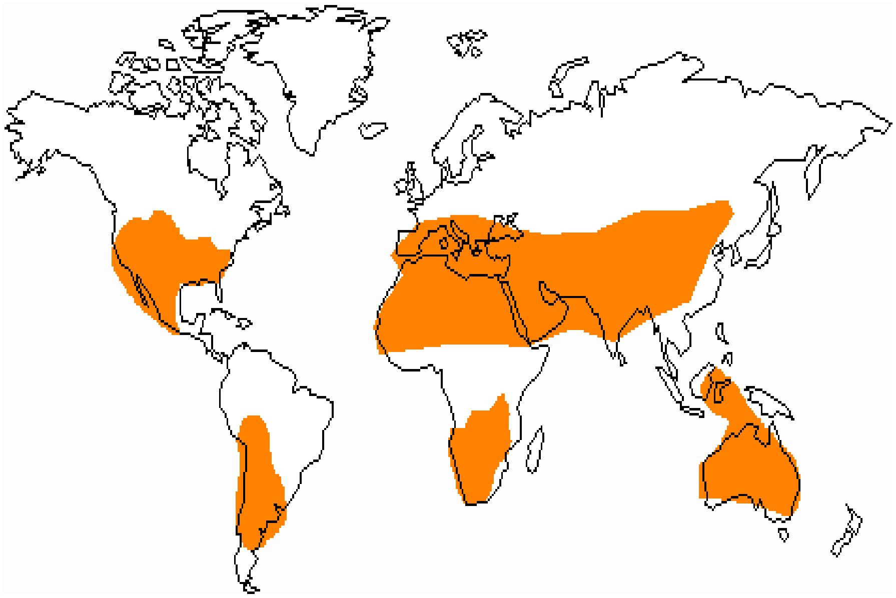
	□Agriculture	□Glazed flat plate collectors □Unglazed flat plate collectors	□Heat exchanger □Medium-large water tank
	□Aquaculture	□Unglazed **flat plate collectors**	□Medium-large water tank
□**Heating - Swimming Pools**	□Outdoor pools	□Unglazed flat plate collectors	□Heat exchanger
	□Indoor pools	□Glazed flat plate collectors	
□**Heating - Ventilation Air**	□All building types	□all Air-based collectors	□By-pass dampers □Make-up air handling units
□**Heating - Buildings**	□Homes / Commercial	□Advanced windows □Transparent insulation □Trombe wall □Liquid-based collectors with home heating system	□Appropriate building materials □Building design □Heat exchanger □Advanced thermal storage
	□Community-wide	□Liquid-based collectors □large-scale arrays	□Seasonal thermal storage □District heating network
	□Greenhouses	□Transparent insulation	
□**Cooling - Buildings**	□Commercial	□Vacuum tube collectors □Glazed flat plate collectors	□Cooling cycles – various
□**Daylighting -Buildings**	□Homes & Commercial	□Advanced windows □Transparent insulation	□Building design
□**Crop Drying**	□Agricultural	□all Air-based collectors	
□**Electricity Generation - Off Grid**	□Cottages / Seasonal homes	□**Photovoltaics – small arrays**	□Batteries □Power Invertors □Small wind turbines or microhydro
	□Power for remote equipment	□**Photovoltaics – small-medium arrays**	

□**Electricity Generation - Distributed Power**	□All building types	□Photovoltaics – building integrated medium-scale arrays	□Power Invertors
	□Remote communities	□Photovoltaics – medium-scale arrays in a hybrid system	□combined with diesel generators on local grid
	□Electric Utilities	□Photovoltaics - large-scale arrays	□Power Invertors □Sun trackers
		□Power tower □**Parabolic** trough	□Steam turbine □High temperature thermal storage
□**Detoxifying - Water**		□Photocatalysts for oxidation	□UV lamps for backup
	□Industrial / Municipal	□Thermal catalysts for oxidation with concentrating collectors	
□**Detoxifying - Air**	□Commercial / Homes	□Photocatalysts for oxidation	□UV lamps for backup
□**Cooking food & H_2O treatment**	□Homes	□**Solar cookers**	

The Solar Resource

The basic resource for all solar energy systems is the **sun**. Knowledge of the quantity and quality of solar energy available at a specific location is of prime importance for the design of any solar energy system. Although the solar radiation (***insolation***) is relatively constant outside the earth's atmosphere, local climate influences can cause wide variations in available insolation on the earth's surface from site to site. In addition, the relative motion of the sun with respect to the earth will allow surfaces with different orientations to intercept different amounts of solar energy.

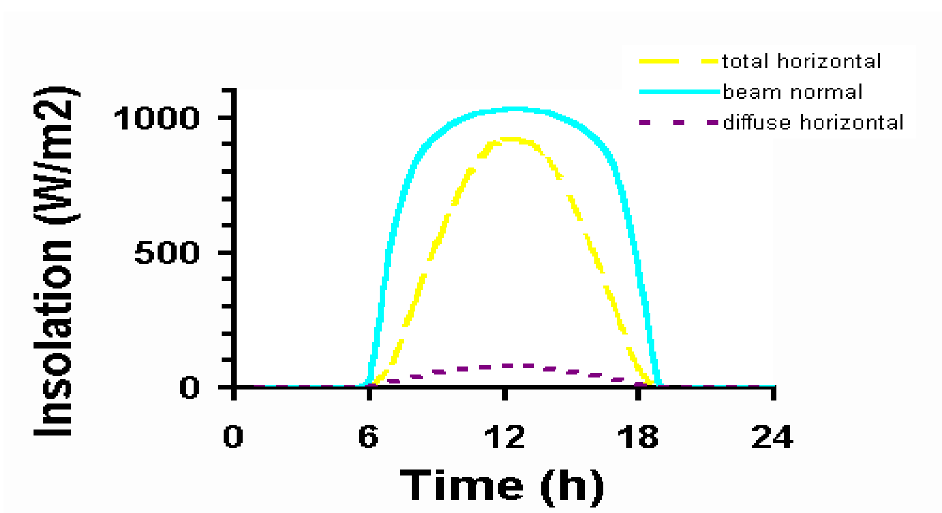
The Figure shows regions of high insolation where solar energy conversion systems will produce the maximum amount of energy from a specific collector field size. However, solar energy is available over the entire globe, and only the size of the collector field needs to be increased to provide the same amount of heat or electricity as in the shaded areas. **It is the primary task of the solar energy system designer to determine the amount, quality and timing of the solar energy available at the site selected for installing a solar energy conversion system.**



Areas of the world with high insolation.

Just outside the earth's atmosphere, the sun's energy is continuously available at the rate of 1,367 Watts on every square meter facing the sun. Due to the earth's rotation, asymmetric orbit about the sun, and the contents of its atmosphere, a large fraction of this energy does not reach the ground.

The outer curve (see below), representing the greatest rate of incident energy, shows the energy coming directly from the sun (*beam normal insolation*) and falling on a square meter of surface area which is pointed toward the sun. The peak rate of incident solar energy occurs around 12:00 noon and is 1,030 Watts per square meter. Over the full day, **10.6 kilowatt-hours** of energy has fallen on every square meter of surface area as represented by the area under this curve.

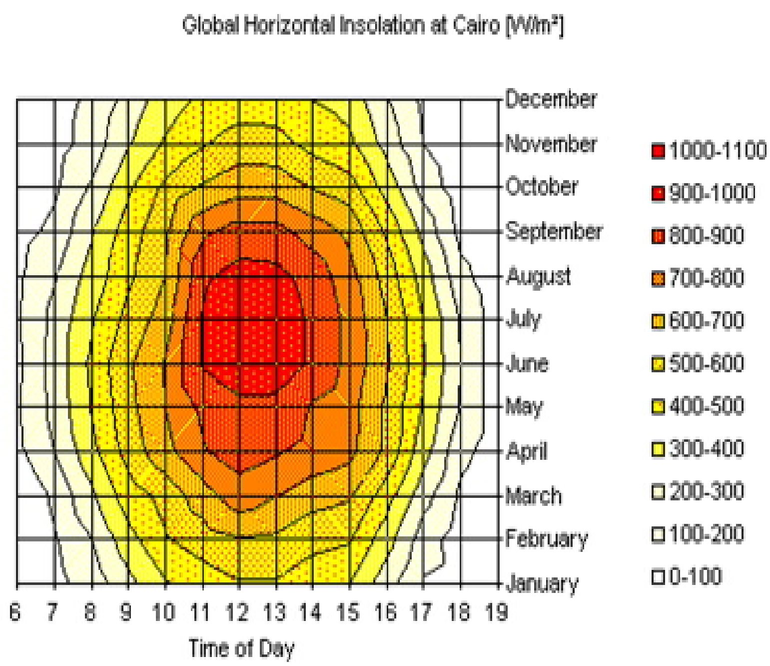


Insolation data from Daggett, California on a clear March day.

The middle curve represents the rate of solar energy falling on a horizontal surface at the same location. For reasons to be discussed later, this curve includes both the energy coming directly from the sun's disc, and also that scattered by the molecules and particles in the atmosphere (*total horizontal insolation*). This scattered energy is shown as the bottom curve (***diffuse insolation***). Over the entire day, **6.7 kilowatt-hours** of solar energy fall on every square meter of horizontal surface, of which 0.7 kilowatt-hours comes from all directions other than directly from the sun.

Techniques for estimating the temporal solar resource at any site on the face of the earth are presented in Chapter 2. In addition, the development and use of computerized meteorological data files is described. These data files based on long-term actual observations, form the time-dependent database of the computerized performance computations contained within this book and, indeed, much of the solar literature.

An example of a complete set of beam normal insolation data for a given location is shown in the Figure(below). Here we see hourly insolation data, summarized over a day, for each month of a year. With this type of data for a specific site, it is possible to predict accurately the output of a solar energy conversion system, whether it is a low temperature thermal system, a high temperature thermal system or a photovoltaic system.



Time and date description of the global, horizontal insolation solar resource for Cairo Egypt.

In addition to estimating the amount of energy coming from the sun, the solar designer must also be able to predict the position of the sun. The sun's position must be known to predict the amount of energy falling on tilted surfaces, and to determine the direction toward which a tracking mechanism

must point a collector. The computation of the position of the sun with respect to any given point on the face of the earth, using **four** parameters (latitude, longitude, date and local time), and some equations to determine the location of the sun in the sky must be known.

A characteristic fundamental to the capture of solar energy is that the amount of energy incident on a collector is reduced by a fraction equal to the **cosine of the angle** between the collector surface and the sun's rays. Knowing the position of the collector (or any other surface for that matter) and the position of the sun equations may be used to predict the fraction of incoming solar energy that falls on the collector. These include situations where the collector is fixed or is tracked about a single axis, no matter what the orientation.

Solar Collectors

The **solar collector** is the key element in a solar energy system. **It is also the novel technology area that requires new understandings in order to make captured solar energy a viable energy source for the future.**

The function of a solar collector is simple; it intercepts incoming insolation and changes it into a useable form of energy that can be applied to meet a specific demand. In the following text, we will develop analytical understandings of **flat-plate** and concentrating collectors, as used to provide heat or electricity. Each type is introduced below.

Flat-plate thermal solar collectors are the most commonly used type of solar collector. Their construction and operation are simple. A large plate of blackened material is oriented in such a manner that the solar energy that falls on the plate is absorbed and converted to thermal energy thereby heating the plate. Tubes or ducting are provided to remove heat from the plate, transferring it to a liquid or gas, and carrying it away to the load. One (or more) transparent (glass or plastic) plates are often placed in front of the absorber plate to reduce heat loss to the atmosphere. Likewise, opaque insulation is placed around the backside of the absorber plate for the same purpose. Operating temperatures up to 125^{o}C are typical.

Flat plate collectors have the advantage of absorbing not only the energy coming directly from the disc of the sun (beam normal insolation) but also the solar energy that has been diffused into the sky and that is reflected from the ground. Flat plate thermal collectors are seldom tracked to follow the sun's daily path across the sky, however their fixed mounting usually provides a tilt toward the south to minimize the angle between the sun's rays and the surface at noontime. Tilting flat-plate collectors toward the south provides a higher rate of energy at noontime and more total energy over the entire day. Figure 1 shows an installation of flat-plate thermal collectors.

Figure 1 Flat-plate thermal solar collectors for providing hot water.(photo courtesy of DOE/NREL, Warren Gretz)

Flat-plate photovoltaic collectors contain an array of individual photovoltaic cells, connected in a series/parallel circuit, and encapsulated within a sandwich structure with the front surface being glass or plastic. Solar energy falls directly upon the photovoltaic cell front surface and produces a small direct current voltage, providing electrical energy to a load. Unlike thermal collectors however, the backside of the panel is not insulated. Photovoltaic panels need to loose as much heat as possible to the atmosphere to optimize their performance.

Like flat-plate thermal collectors, flat-plate photovoltaic collectors (panels) absorb both energy coming directly from the sun's disc, and diffuse and reflected energy coming from other directions. In general, flat-plate photovoltaic panels are mounted in a fixed position and tilted toward the south to optimize noontime and daily energy production. However, it is common to see flat-plate photovoltaic panels mounted on mechanisms that track the sun about one tilted axis, thereby increasing the daily output of the panels.

Figure 2 Flat-plate photovoltaic collector applications.(photos courtesy of DOE/NREL, Warren Gretz)

When higher temperatures are required, concentrating solar collectors are used. Solar energy falling on a large reflective surface is reflected onto a smaller area before it is converted into heat. This is done so that the surface absorbing the concentrated energy is smaller than the surface capturing the energy and therefore can attain higher temperatures before heat loss due to radiation and convection wastes the energy that has been collected. Most concentrating collectors can only concentrate the parallel insolation coming directly from the sun's disk (beam normal insolation), and must follow (track) the sun's path across the sky. Four types of solar concentrators are in common use; parabolic troughs, parabolic dishes, central receivers and Fresnel lenses. Figure 3 shows these concepts schematically.

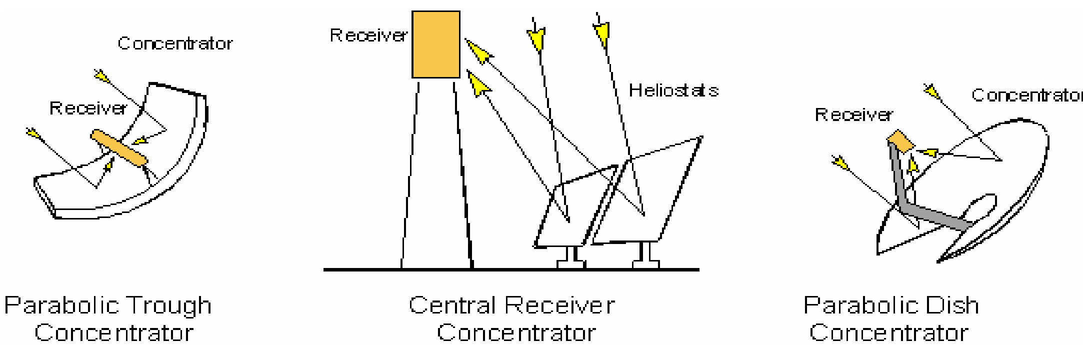


Figure 3 Three commonly used reflecting schemes for concentrating solar energy to attain high temperatures.

A parabolic trough concentrates incoming solar radiation onto a line running the length of the trough. A tube (receiver) carrying heat transfer fluid is placed along this line, absorbing concentrated solar radiation and heating the fluid inside. The trough must be tracked about one axis. Because the surface area of the receiver tube is small compared to the trough capture area (aperture), temperatures up to 400^{o}C can be reached without major heat loss

A parabolic dish concentrates the incoming solar radiation to a point. An insulated cavity containing tubes or some other heat transfer device, is placed at this point absorbing the concentrated radiation and transferring it to a gas. Parabolic dishes must be tracked about two axes.

A central receiver system consists of a large field of independently movable flat mirrors (heliostats) and a receiver located at the top of a tower. Each heliostat moves about two axes, throughout the day, to keep the sun's image reflected onto the receiver at the top of the tower. The receiver, typically a vertical bundle of tubes, is heated by the reflected insolation, thereby heating the heat transfer fluid passing through the tubes. A Fresnel lens concentrator, such as shown in Figure 4 uses *refraction* rather than reflection to concentrate the solar energy incident on the lens surface to a point. Usually molded out of inexpensive plastic, these lenses are used in photovoltaic concentrators. Their use is not to increase the temperature, but to enable the use of smaller,

higher efficiency photovoltaic cells. As with parabolic dishes, point-focus Fresnel lenses must track the sun about two axes.

Figure 4 A central receiver system. (courtesy of Sandia National Laboratories, Albuquerque)

Figure 5 Two-axis tracking parabolic dish collectors. (courtesy of Schlaich, Bergermann und Partner)

Figure 6 A single-axis tracking parabolic trough collector. **(courtesy of Kramer Junction Operating Company)**

Figure 7 A concentrating photovoltaic collector using Fresnel lenses. **(courtesy of Amonix Corp.)**

Need for Storage

Like with any other power plant, solar power plant *output* must satisfy the demands of the utility market. During peak demand periods, kilowatt-hour prices are high and financial incentives are high for guaranteed supply. Solar plant *input* is limited by diurnal, seasonal and weather-related insolation changes. In order to cope with these fluctuations, the solar plant input may be backed up by fossil fuels, or the solar changes may be mitigated by a

buffering storage system. The choice depends on demands, system and site conditions,

In thermal solar power plants, thermal storage and/or fossil backup act as:

- an output management tool to prolong operation after sunset, to shift energy sales from low revenue off-peak hours to high revenue peak demand hours, and to contribute to guaranteed output

- an internal plant buffer, smoothing out insolation charges for steadying cycle operation, and for operational requirements such as blanketing steam production, component pre-heating and freeze protection.

Photovoltaic plants in general need no internal buffer, and output management can be achieved with battery or other electrochemical storage, pumped hydroelectric storage, or with diesel-generator backup.

Figure 8 One of the steam cycle power cycles at the Kramer Junction solar energy generating system.(photo courtesy of DOE/NREL, Warren Gretz)

Solar electricity generation costs and feasibility of the project highly depend on the project site itself. A good site has to have a high annual beam insolation to obtain maximum solar electricity output. It must be reasonably flat to accommodate the solar field without prohibitive expensive earth works. It must also be close to the grid and a substation to avoid the need to build expensive electricity lines for evacuating the power. It needs sufficient water supply to cover the demand for cooling water of its steam cycle. A backup fuel must be available for granting firm power during the times when no solar energy is available. Access roads must be suitable for transporting the heavy equipment like turbine generators to the site. Skilled personnel must be available to construct and operate the plants.

Economic and Environmental Considerations

The most important factor driving the solar energy system design process is whether the energy it produces is economical. Although there are factors

other than economics that enter into a decision of when to use solar energy; i.e. no pollution, no greenhouse gas generation, security of the energy resource etc., design decisions are almost exclusively dominated by the ‘levelized energy cost’. This or some similar economic parameter, gives the expected cost of the energy produced by the solar energy system, averaged over the lifetime of the system.

Commercial applications from a few kilowatts to hundreds of megawatts are now feasible, and plants totaling 354 MW have been in operation in California since the 1980s. Plants can function in dispatchable, grid-connected markets or in distributed, stand-alone applications. They are suitable for fossil-hybrid operation or can include cost-effective storage to meet dispatchability requirements. They can operate worldwide in regions having high beam-normal insolation, including large areas of the southwestern United States, and Central and South America, Africa, Australia, China, India, the Mediterranean region, and the Middle East.

Solar Water Heaters

WHAT IS A SOLAR WATER HEATER:

A solar water heater is extremely simple.

On a typical single-family residence, there will typically be one or two solar collector panels on the roof.

The panels resemble skylights, and will be about 1 m and 2 m long.
The cold water supply is connected to the solar storage tank. Water to be heated circulates between the storage tank and the solar collectors. The output from the solar storage tank becomes the cold water connection to the conventional gas, electric or oil water heater. When a hot tap is opened, pre-heated water is drawn from storage into the conventional ("auxiliary") water heater. The burner or electric element turns on only if the temperature cannot be maintained by the solar heater. Most properly-designed solar water heaters will supply 70 per cent or more of all the energy needed for water heating.

Solar water heaters—also called solar domestic hot water systems—can be a cost-effective way to generate hot water for your home. They can be used in any climate, and the fuel they use—sunshine—is free.

How They Work

Solar water heating systems include storage tanks and solar collectors. There are two types of solar water heating systems: active, which have circulating pumps and controls, and passive, which don't.

Most solar water heaters require a well-insulated storage tank. Solar storage tanks have an additional outlet and inlet connected to and from the collector. In two-tank systems, the solar water heater preheats water before it enters the conventional water heater. In one-tank systems, the back-up heater is combined with the solar storage in one tank.

To get the full benefits of a solar heater you must have an area for the solar collectors that is large enough and has the proper exposure to the sun. A flat roof is ideal because the collectors can usually be oriented to face the sun directly very easily. If you install the collectors on a pitched roof, the ideal direction the roof should face is south.

The collector area required will depend on the daily amount of hot water use, the type of collectors used, the orientation of the collectors and your geographic location. If you consider a standard "package", you should be sure it is sized appropriately for your specific installation.

If you choose a "Passive" solar water heater, the storage tank(s) will be on the roof. In this event, simple structural bracing may be required. Active solar systems do not normally require structural calculations or roof bracing, because the weight of the collectors is well within normal roof load limits.

An "Active" solar water heater uses a small pump for solar collector circulation, and does not require a tank on the roof. A "Passive" solar heater depends on thermosyphon action, so does not use a pump, but tanks(s) must be on the roof.

Three types of solar collectors are used for residential applications:

- **Flat-plate collector**
  Glazed flat-plate collectors are insulated, weatherproofed boxes that contain a dark absorber plate under one or more glass or plastic (polymer) covers. Unglazed flat-plate collectors—typically used for solar pool heating—have a dark absorber plate, made of metal or polymer, without a cover or enclosure.

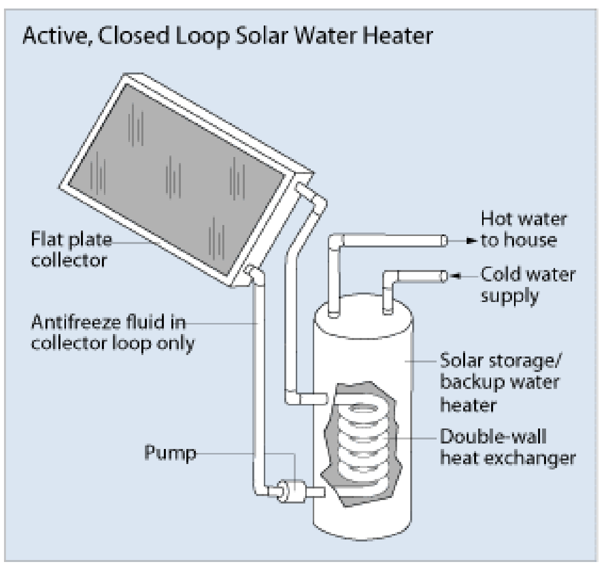
- **Integral collector-storage systems**
  Also known as ICS or *batch* systems, they feature one or more black tanks or tubes in an insulated, glazed box. Cold water first passes through the solar collector, which preheats the water. The water then continues on to the conventional backup water heater, providing a reliable source of hot water. They should be installed only in mild-freeze climates because the outdoor pipes could freeze in severe, cold weather.

- **Evacuated-tube solar collectors**
  They feature parallel rows of transparent glass tubes. Each tube contains a glass outer tube and metal absorber tube attached to a fin. The fin's coating absorbs solar energy but inhibits radiative heat loss. These collectors are used more frequently for U.S. commercial applications.

There are two types of active solar water heating systems:

- **Direct circulation systems**
  Pumps circulate household water through the collectors and into the home. They work well in climates where it rarely freezes.

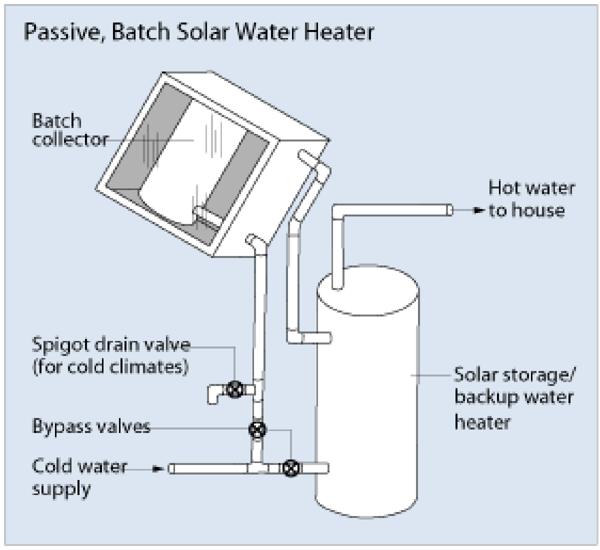
- **Indirect circulation systems**
  Pumps circulate a non-freezing, heat-transfer fluid through the collectors and a heat exchanger. This heats the water that then flows into the home. They are popular in climates prone to freezing temperatures.



Passive solar water heating systems are typically less expensive than active systems, but they're usually not as efficient. However, passive systems can be more reliable and may last longer. There are two basic types of passive systems:

- **Integral collector-storage passive systems**
  These work best in areas where temperatures rarely fall below freezing. They also work well in households with significant daytime and evening hot-water needs.

- **Thermosyphon systems**
  Water flows through the system when warm water rises as cooler water sinks. The collector must be installed below the storage tank so that warm water will rise into the tank. These systems are reliable, but contractors must pay careful attention to the roof design because of the heavy storage tank. They are usually more expensive than integral collector-storage passive systems.



Solar water heating systems almost always require a backup system for cloudy days and times of increased demand. Conventional storage water heaters usually provide backup and may already be part of the solar system package. A backup system may also be part of the solar collector, such as rooftop tanks with thermosyphon systems. Since an integral-collector storage system already stores hot water in addition to collecting solar heat, it may be packaged with a demand (tankless or instantaneous) water heater for backup.

Making a solar water heater

In this activity, we can see how solar water heaters take advantage of the fact that hot water rises.

Materials (for small group)

large cardboard tray, approximately 60 × 30 × 15 × centimetres (made by cutting down a cardboard carton)

sheet of glass, larger than 60 × 30 centimetres

6 metres of plastic tubing or garden hose

2-litre plastic bottle

cardboard carton (big enough to hold the plastic bottle)

thermometer

scissors with pointed ends

plasticine

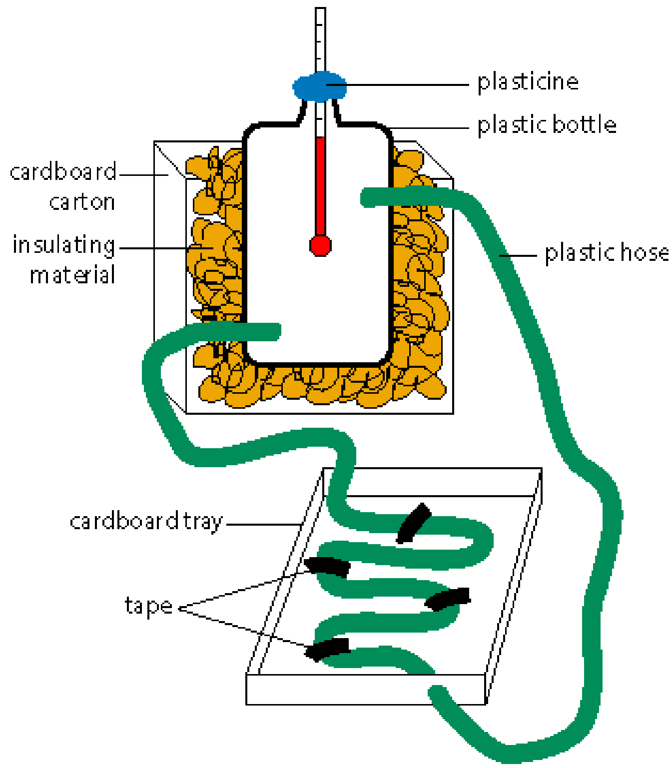
sticky tape

water

black and white poster paints

sheet of clear plastic, larger than 60 × 30 centimetres

a variety of insulating materials (eg, old clothing, sawdust, plastic foam, crumpled newspapers)



Set up the model solar water heater (as shown in the diagram) and place it in a sunny position.

Fill the bottle and the plastic tubing with water.

Record the temperature of the water after the solar water heater has been in sunlight for 20 minutes.

Test for the effect on the temperature of altering variables (eg, clear plastic versus glass covering the box; various insulating materials around the bottle; the colour of the bottom of the cardboard box; the angle at which the box is tilted).

Questions

a. Why was it important to have one end of the plastic hose entering at the top of the bottle and the other end entering at the bottom?
b. Why did the model solar water heater have a long length of the plastic hose positioned in the bottom of the tray.

Teachers notes

a. One of the holes should be at the top of the bottle and the other at the bottom to ensure that circulation and mixing occurs as the water is heated.

Positioning as much of the tubing as possible across the bottom of the box ensures that the maximum area of tubing is exposed to the sun.

Solar dryers

3.3 Other Devices

In addition to the cooking, mechanical and electrical devices there are other mixed type of devices that tap the renewable energy and serve different purposes of the farmers and rural populations.

3.3.1 Drying

Open sun drying of various agricultural produce is the most common application of solar energy. With the objective of increasing drying rate and improving quality of the produce natural convection and forced convection type solar dryers have been developed for various commodities. The movement of air in the forced convection solar dryer is through a power blower, whereas in natural convection solar dryer air moves through the produce due to natural thermal gradient.

3.3.1.1 Domestic Solar Dryer

This is a small dryer meant for domestic uses of drying small quantities of products such as vegetables, fruits, condiments and spices. In this dryer, the convection of heated air is natural due to difference in temperatures. Solar energy is intercepted on the inclined aperture, which is glazed for trapping infrared radiation, and prevents unnecessary circulation of ambient air thereby maintaining the requisite temperature inside. The drying trays have been arranged one over the other on an inclined plane so that there is free circulation of heated air through the mass kept for drying. The products can be dried under shade or exposed to sunrays as desired. The dryer has provision for changing inclination of the aperture by 15° to capture more solar energy depending upon the season. Castor wheels make orientation easy in order to capture maximum solar radiation. The drier may be left unattended even during rains, as the products kept inside are not affected.

Step Type Solar Cocoon Stifler

Silk cocoon stifling is generally carried out using an electric oven or by using firewood and boiling water. The heat needed to kill the pupa is obtained from solar radiation in a solar cocoon stifler. If the pupas are not killed at the right time they grow out of the cocoon,

ays time is available for reeling the silk fibres. The solar cocoon stifler is a box type unit that is provided with insulation and double glazed cover for trapping solar heat. Wire mesh trays are arranged horizontally inside the stifler and can be loaded easily by opening the side panels. It has a small fan for re-circulating air for uniform heat distribution. An electric heater of 2 KW and thermostatic control is also provided to supply adequate heat during adverse weather. The quality of cocoon stifled in the solar stifler is similar to the cocoon stifled in the conventional process using the electric oven.

Simple Pyramid Shaped Solar Dryer

This dryer is conduction-convection type, pyramid shaped solar dryer with a base to height ratio of 1:1.5. The frame of the dryer is fabricated from wood and the trays (which also act like racks) are also of wooden frame and wire mesh. UV stabilized black polythene sheets cover the dryer. Since the wooden-wire-mesh trays are stored vertically, one over the other, the dryer allows an effective drying area equal to twice the size of the base area.
In summers the dryer attains temperatures of up to 15º to 20ºC more than ambient and in winters about 5º to 10ºC more than the ambient. Sunlight falling on the black UV stabilized polythene sheet heats up the sheet.

The heat absorbed by the sheet heats the air inside the pyramid shaped dryer. As the air gets heated inside, the convectional currents are initiated due to variations in the air densities. Hot air moving up to the top of the dryer carries moisture as vapour from vegetables or fruits kept inside for drying in the wooden-wire-mesh trays/ racks. The holes provided at the top of the dryer allow the hot vapour to escape. Comparative colder air is drawn from outside through holes provided at the base of the dryer.

This Cycle of hot air escaping from the top and colder air being drawn from the base of the dryer removes the moisture and dehydrating the materials, facilitating faster drying of the vegetables, fruits or herbs in this solar dryer.
Fruits like apple, banana and vegetables like ladies finger, bitter gourd, cauliflower, onions etc. can be dried in this dryer. Since the materials do not directly come in contact with Sunlight in this dryer, the materials retain their Colour on drying. The green leafy materials, like spinach, mehandi (henna), tulsi (basil leaves) and neem (Margosa) leaves dried in this solar dryer retain almost its natural green colour even when dried. Standard model solar dryer (shown in the photo) can dry about 20-kg of fresh vegetables, reducing weight to 2 to 3-Kg in two Sunny days.